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THE LEOPARDITE (QUARTZ PORPHYRY) OF NORTH CAROLINA.[1]

By THOMAS L. WATSON.

INTRODUCTORY STATEMENT.

While engaged, during the past summer, in a study of the granites of North Carolina for the State Survey, opportunity offered for examination in the field of the well-known and interesting rock called "leopardite," which occurs near Charlotte in Mecklenburg county. Knowledge of the occurrence of this rock in the state dates back many years, and brief descriptions of it have been published from time to time by different writers, as noted below in the appended references.

In 1853 Dr. Hunter[2] briefly described, megascopically, the general appearance, including locality, of the leopardite found near Charlotte, Mecklenburg county, North Carolina. He says: "It is noticed by Professor Shepard, under the head of feldspar, as the leopard stone of Charlotte, North Carolina." Professor Shepard regarded it as composed of compact feldspar and quartz spotted by the oxides of iron and manganese. Hunter suggested the propriety of retaining the name "leopardite," for the reason that it is quite characteristic of a rather unique rock. In the same paper the author refers to a second locality in Lincoln county, North Carolina, where leopardite had recently been found. Concerning the character of the rock in Lincoln county, he says: "The pervading stripes are, however, generally finer; and when broken diagonally, it presents a handsome aborescent appearance."

In 1862 Dr. F. A. Genth[3] described the leopardite occur-

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[2] C. L. Hunter, "Notices of the Rarer Minerals and New Localities in Western North Carolina," *American Journal of Science*, Vol. XV, (1853, 2d ser.), p. 377.

[3] F. A. Genth, "Contributions to Mineralogy," *ibid.*, Vol. XXXIII, (1862, 2d ser.), pp. 197, 198.

ring near Charlotte as a true porphyry, and gave some general results of a microscopical examination of thin sections of the rock, including a chemical analysis. Still a third locality in North Carolina where leopardite is reported to be found is referred to by Genth, namely, near the Steel mine in Montgomery county.

More recently the leopardite occurring near Charlotte has been noted by Merrill[1] and Lewis[2]. After briefly describing the general appearance of the rock, Professor Merrill makes further statement of its economic value. In connection with his work on the building-stones of North Carolina, Lewis visited the locality to the east of Charlotte, where the leopardite is exposed, and, so far as contained in published accounts of the rock known to me, he was the first to note its true geological occurrence.

Quartz porphyries in association with other closely similar acid volcanic rocks are developed, in places, over the central and the northwestern parts of the state. So far as known at present, the areas of acid volcanic rocks are confined to the volcanic belt which skirts the western margin of the Triassic sandstone in the eastern Piedmont region,[3] and to several of the extreme northwest counties[4] of the state. These rocks show no essential differences, so far as they have been studied, from certain areas of similar ones which occur and are traced at irregular intervals northward along the Atlantic border region of North America as far as Newfoundland.

Of those occurrences in North Carolina, the quartz porphyry found near Charlotte is the only one visited by me that

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[1] George P. Merrill, Stones for Building and Decoration (New York, 1897), 2d ed., pp. 272, 273.

[2] J. V. Lewis, Notes on Building and Ornamental Stone, *First Biennial Report of the State Geologist, N. C. Geological Survey*, 1893, p. 102.

[3] George H. Williams, "The Distribution of Ancient Volcanic Rocks Along the Eastern Border of North America," *Journal of Geology*, Vol. II (1894), pp. 1-32; J. S. Diller, "Origin of Paleotrochis," *American Journal of Science*, Vol. VII (1899, 4th ser.), pp. 337-42.

[4] A. Keith, *Bulletin No. 168*, U. S. Geological Survey, p. 52; *Geologic Atlas of the United States*, "North Carolina-Tennessee, Cranberry Folio," 1903.

shows the characteristic spotted appearance so suggestive of the name "leopardite." Except for the mottled or spotted appearance produced by rounded black areas of metallic oxides, the Charlotte rock differs but slightly, if at all, in essential characters from quartz porphyries described from other localities. (See table of analyses on p. 229).

LOCATION AND OCCURRENCE.

The leopardite is exposed in a number of small outcrops at Belmont Springs, about one and a half miles east of Charlotte. Beginning on top of the hill, several hundred yards above the spring the rock is traced in outcrops over the surface for a distance of a quarter to a half mile in a north 30° east direction. It forms a true dike, intersecting a medium textured and colored, sheared and crushed, biotite granite; and, so far, as it was possible to determine, the dike nowhere exceeds twenty-five feet in width, with a smaller average cross-section. A small opening in one of the outcrops from which some of the rock has been blasted reveals a sharp contact between the quartz porphyry and the inclosing granite.

MEGASCOPIC DESCRIPTION.

The fresh rock is nearly white, tinged the faintest greenish in places, and penetrated by long parallel streaks or pencils of a dead black color. When broken at an angle to the direction of the pencils, the rock surface appears spotted with rounded, irregular black points, ranging in size up to half an inch in diameter. At times the roundish points are somewhat irregular and only partially developed, as shown in the lower left half of Fig. 1. These may be crowded close together over the surface, as seen in the figure, or they may be entirely absent from some areas and irregularly distributed at wide intervals over others, as indicated in Fig. 3. Indeed, the black points are reported to fail entirely in the rock as the dike is traced northward, when the rock assumes a uniformly light color throughout. However, every outcrop and specimen of the rock seen by me contained them.

A section cut parallel to the direction of the pencils presents a surface streaked with long, somewhat irregular, though roughly parallel, black lines, more or less perfect dendritic or fern-like forms (Figs. 2 and 3). I was shown recently a large slab of the rock collected from one of the outcrops since my examination in the summer of 1903, which, for perfection and delicacy of tracery in fern-like forms, was beautiful beyond description. The black streaks or pencils which characterize the rock are composed of a staining of the oxides of manganese and iron.

The rock is cryptocrystalline in texture, breaking with a conchoidal fracture, and is intensely hard and tough. Minute quartz crystals of doubly terminated pyramidal faces are distributed through the rock at irregular wide intervals. These are nowhere abundant in the rock, but they are always present to some extent, and consist both of the light-colored and dark, smoky, vitreous quartz. Indeed, unless carefully examined, the rock would ordinarily be pronounced non-porphyritic in texture, so small and scattering are the porphyritically developed quartzes. Megascopically, porphyritic texture is nowhere particularly emphasized in the rock, but its slight development is best seen on a weathered surface of the stone, where the unaltered quartz crystals, though few in number and widely scattered, contrast more strongly with the weathered surface and appear more conspicuous than in the fresh rock. Feldspars are also porphyritically developed, as described below, though the phenocrysts are difficult of differentiation in hand specimens of the rock.

MICROSCOPICAL DESCRIPTION.

In thin sections the rock consists of a holocrystalline groundmass and scattered small porphyritic crystals. Flow-structure is not exhibited in the groundmass, and the phenocrysts indicate no orientation with respect to each other. The groundmass is micro-granitic in structure, though some sections show much of the micro-granophyric structure, with an irregular radial, spherulitic, structure developed in greater or less

proportion in all of the sections studied. When they form complete spheres, which is rarely the case, they usually exhibit somewhat irregular ragged peripheries, and further show usually between cross nicols a very indefinite black cross. The form of the grains in the typical micro-granitic areas of the groundmass is sharp and allotriomorphic to partially idiomorphic. The principal groundmass minerals are feldspar and quartz, with much light-colored mica, and an occasional inclusion of prismatic apatite and zircon. Irregular minute grains of iron oxide are scattered through the sections, and stained areas from manganese and iron oxides, forming the dark spots and pencils in the hand specimens, occur. The thin sections are characterized by the complete absence of ferro-magnesian minerals.

Feldspar is apparently in largest quantity, and is composed of both potash and plagioclase species. Occasional grains of microcline are recognized which show the characteristic microcline twinning. The unstriated feldspar grains so strongly resemble quartz that it is impossible in many cases to distinguish them without the application of optical tests. Optical tests show the plagioclase to be albite—a circumstance entirely confirmed by the chemical analysis of the rock given below in the table of analyses under I, in which only the barest trace of lime is indicated, with soda in large amount and in excess of the potash. Some of the plagioclase exhibits polysynthetic twinning according to the albite law, and at times assumes lath-shaped forms. The feldspar substance is generally fresh, but the individual grains are usually rendered dark by abundant, closely crowded, minute, dark, dust-like particles, the identity of which could not be made out.

Quartz is of the usual kind and presents no noteworthy features, further than its occurrence in small mosaics of interlocking grains, which occupy at times distinct areas in some of the thin sections.

Light-colored mica, tinged a faint yellow, is very generally distributed through the sections, in the form of irregular minute shreds, groups, and aggregated masses, the folia of which are at times imperfectly arranged radially about a common center.

A part, at least, of the mica is clearly secondary, while some of it is yet doubtful as to origin, whether primary or secondary. Its general appearance and association in the sections might very well indicate secondary formation for all of it.

Phenocrysts of both quartz and feldspar occur in well-developed idiomorphic forms, usually in rectangular and squarish cross-sections. In the thin sections studied, phenocrysts of feldspar are more abundant than quartz; and while the porphyritic texture is poorly developed in the hand specimens, it is very pronounced in the thin sections. The quartz phenocrysts show irregular fractures free from impurities, strained shadows, and occasionally inclose grains of feldspar. The porphyritic feldspars show in part broadly twinned bands of plagioclase, and untwinned orthoclase. These are frequently rendered nearly opaque from innumerable, closely crowded, dark inclusions not identifiable, along with minute spangles of colorless mica. Zonal structure is rarely observed, and cleavage is usually wanting. Around the borders of several of the feldspar phenocrysts slight embayments, produced by incipient resorption, are noticeable.

Several of the sections were so cut as to include areas of the black pencils which characterize the rock, megascopically. These are distinguished, microscopically, from the white portions of the groundmass only by a distinct medium-to-dark yellowish-brown staining, somewhat resembling that of limonite stain frequently observed discoloring tiny areas of the rock, derived from the partial leaching of any iron-bearing constituent in igneous rocks. No definite source of the staining was entirely indicated in any of the sections, but the areas clearly represent percolation of solutions of manganese and iron salts through the rock. Why the definite arrangement into long pencils and dedritic forms manifested megascopically, evidence is again lacking, for the textural relations of the minerals in the discolored areas are precisely the same microscopically, as for other portions of the rock. The character of the staining suggests that the spotted and streaked appearance of the rock is a

superficial phenomenon, and perhaps does not extend to any very great depth.

CHEMICAL COMPOSITION.

The chemical composition of the rock is given in analysis I of the table of analyses. The analysis of leopardite was made by Dr. F. A. Genth from the freshest fragments of the groundmass obtainable. The most striking features of the analysis are (1) the very acid character of the rock, manifested in the high SiO_2 content; (2) the nearly complete absence of CaO and MgO; and (3) the increased Na_2O which is in excess of the K_2O. The analysis, however, harmonizes closely with the microscopic study of thin sections of the rock, for the absence of ferromagnesian minerals accounts for the very slight amount of MgO present, while the practical absence of CaO and the large percentage of Na_2O prove the plagioclase to be albite, as indicated above by the microscope.

TABLE OF ANALYSES.

	I	II	III	IV	V
SiO_2	75.92	79.75	79.57	73.12	72.85
Al_2O_3	14.47	10.47	11.41	14.27	13.78
Fe_2O_3	0.88	0.64	0.20	0.51	1.87
FeO	----	0.92	0.70	0.26	0.36
MgO	0.09	0.13	a little	0.24	0.42
CaO	0.02	0.15	0.21	1.10	0.87
Na_2O	4.98	1.36	3.46	3.43	4.14
K_2O	4.01	6.01	3.52	4.90	4.49
H_2O–110°C.	----	0.08	0.18	0.68	0.22
H_2O+110°C.	0.64	0.60	0.61	0.73	0.54
TiO_2	----	0.15	0.11	0.08	0.44
P_2O_5	----	trace	trace	0.03	0.13
ZrO_2	----	0.05	----	----	----
MnO	----	trace	----	0.06	0.06
SrO	----	trace	----	trace	----
BaO	----	0.06	0.05	trace	----
Li_2O	----	trace	----	trace	----
NiO	----	----	----	----	0.20
CO_2	----	----	----	0.77	----
Total	100.01	100.37	100.02	100.18	99.87

I. Quartz porphyry (leopardite), one and a half miles east of Charlotte, Mecklenburg county, North Carolina. *American Journal of Science*, Vol. XXXIII (1862, 2d ser.), p. 198. F. A. Genth, analyst.

II. Quartz porphyry—two and a half miles northwest of Blowing Rock, Watauga county, North Carolina. Petrographic data by Arthur

Keith. Contains quartz and orthoclase, with subordinate sericite, chlorite and biotite. W. F. Hillebrand, analyst. *Bulletin No. 168*, U. S. Geological Survey, p. 52.

III. Spherulitic rhyolite—Sam Christian gold mine, Montgomery county, North Carolina. Described by J. S. Diller, *American Journal of Science*, Vol. VII (1899, 4th ser.), p. 341. W. F. Hillebrand, analyst. *Bulletin No. 168*, U. S. Geological Survey, p. 53.

IV. Quartz porphyry. Yogo Rock, sheet at head of Belt and Running Wolf Creeks, Little Belt Mountains, Montana. Described by Weed and Pirrson. *Twentieth Annual Report*, Part III, U. S. Geological Survey, pp. 520 ff. W. F. Hildebrand, analyst. *Bulletin No. 168*, U. S. Geological Survey, Vol. III, p. 125.

V. Quartz porphyry.—Six miles east of Ironton, Missouri. Described by E. Haworth, *Annual Report*, Missouri Geological Survey, Vol. VIII, 1894, p. 181. Melville, analyst.

This analysis is compared in the table with a recent, more detailed one (II), of a quartz porphyry occurring in the northwestern part of the state, and with a spherulitic rhyolite (III) found east of the Charlotte locality in Montgomery county; and with analyses IV and V of well-known quartz porphyries occurring in other parts of the United States. A perusal of the figures given in the table will make clear the general similarity of the rocks, notwithstanding the rather striking differences indicated in some of the constituents.

WEATHERING.

In some exposures of the leopardite the weathered surface of the rock, which is still hard and firm, presents a lusterless, dead, chalk like whiteness, the black spots of which are more or less bleached, changed from black to a reddish-brown in color. This alteration is brought out fairly well in Fig. 4, which is a photograph of a hand specimen of the partially weathered rock, reproduced one-half natural size. Bleaching of the spots is more emphasized along the top of the specimen, shown in the figure (4) in the contrasted lighter color of these spots to others in the same figure When Fig. 4 is compared with those of the fresh rock, Figs. 1, 2 and 3, it is noticeable that all the spots in it have undergone some leaching, as indicated in their color being less intense or deep than for those in the fresh specimens of the rock.

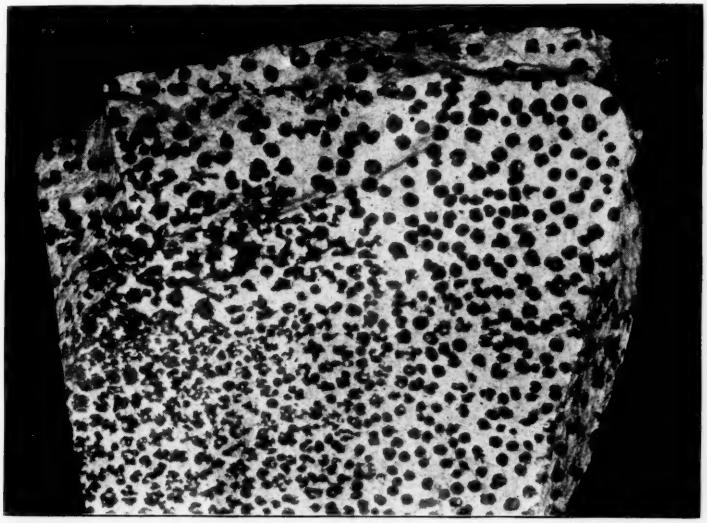

FIG. 1. - View showing the spotted appearance of the rock on a surface broken at right angles to the longer direction of the pencils. Photographed from a hand specimen. (One-half natural size.)

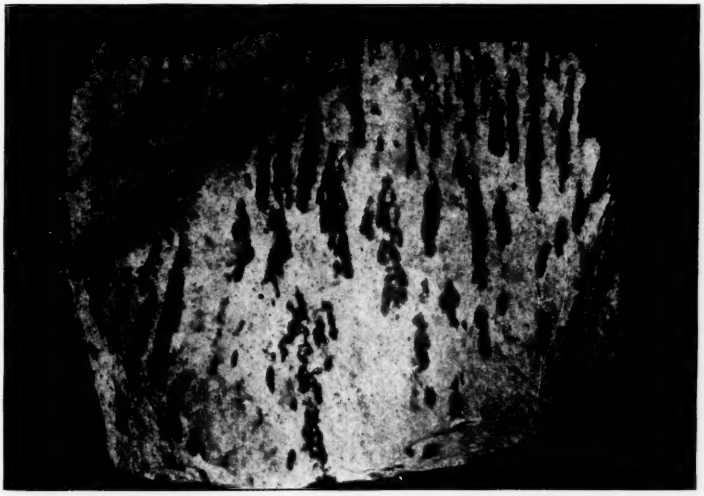

FIG. 2.—View showing approximately parallel black streaks and pencils on rock surface broken parallel to the direction of the pencils. Photographed from hand specimen. (One-half natural size.)

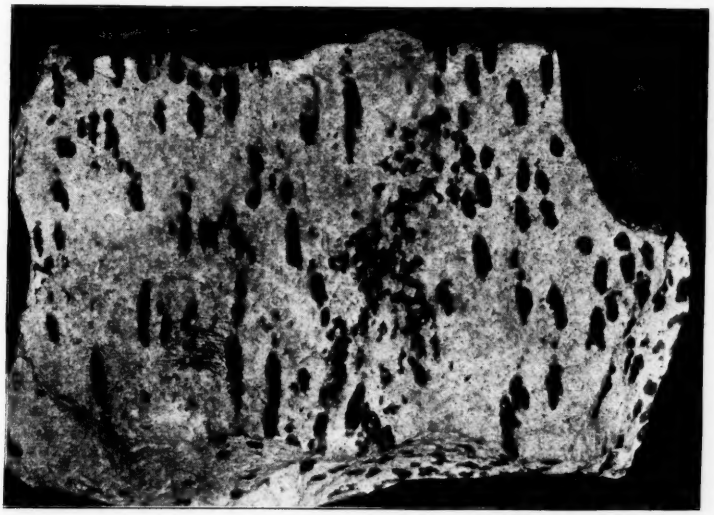

FIG. 3.—View showing partially spotted and partially streaked rock, with tendency toward arborescent form manifested near the middle of the picture. Surface broken at an angle intermediate between that of Figs. 1 and 2, Plate XIII. Photographed from hand specimen. (One-half natural size.)

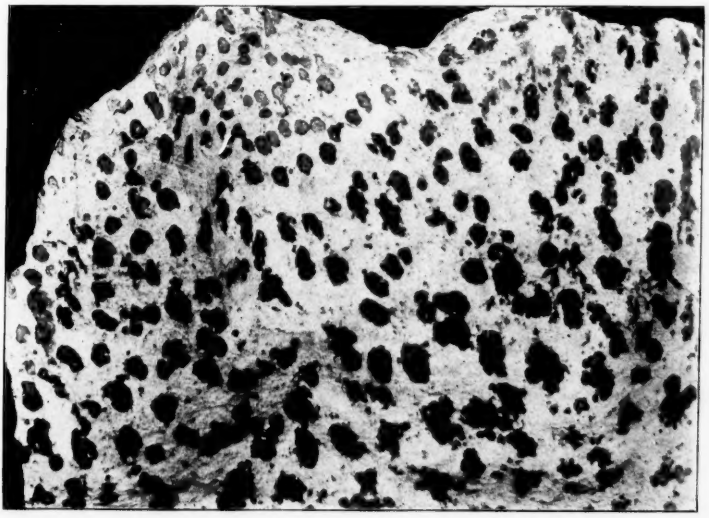

FIG. 4.—View showing weathered surface of the rock. Partial leaching of the dark spots is emphasized in the upper portion of the picture. Photographed from hand specimen. (One-half natural size.)